ASSESSING OCEAN MODELING AND DATA ASSIMILATION REQUIREMENTS

An activity sponsored by the National Science Foundation, Ocean Sciences Division

2. Report on Workshop to Discuss Community Needs for Ocean Global Circulation Modeling

NCAR, Boulder, CO
7-8 April 1997

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REPORT ON MEETING TO DISCUSS COMMUNITY NEEDS FOR OCEAN GENERAL CIRCULATION MODELING

NCAR, Boulder CO
7 - 8 April, 1997

I. BACKGROUND

The Ocean Sciences Division of the National Science Foundation, directed by Mike Purdy, is considering future requirements for infrastructure needed by the ocean sciences community in the pursuit of ocean modeling, including data assimilation. Purdy sent a message on August, 30, 1996 to Worth Nowlin (Chair of the U.S. WOCE Science Steering Committee) stating:

> "...we believe that an important component of the future global ocean sciences is the creation of the infrastructure and environment in which data assimilation, integration, modeling, and interpretation of large diverse data sets can take place. This is an issue that extends well beyond WOCE and we encourage you to lead a community-based effort to provide us with advice concerning the form that support for such capability should take. We consider it important to design a model that can sustain growth over a substantial period of time because it is inevitable that the beginnings will be modest, but the requirement will grow substantially over the next decade.
>
> It is logical that WOCE should provide the leadership for this activity, but it is important that the effort be...a service to the community as a whole. ... Would it be useful, perhaps, to form a small high-level 'executive' steering group...to serve as a leadership group and attempt from the start to establish the broad non-partisan nature of this initiative? In recognition of the broad-based nature of this planning activity we...would supplement it at the Division level...."

An ad hoc steering committee for ocean modeling advances consisting of Andrew Bennett (community at large), Russ Davis (ocean CLIVAR), Hugh Ducklow (JGOFS), Worth Nowlin (WOCE), Thomas Powell (GLOBEC), and Doug Wallace (DOE carbon dioxide program) was established in September 1996. A series of community discussions to assess requirements for future computational work by the ocean science community, including both model development and data assimilation, was considered.

The first meeting in this series was held in Dallas, TX, in February 1997 and concentrated on the synthesis needs of several global programs. The intent of the meeting was to begin the process of exploring community requirements for data assimilation and to discuss whether a community ocean data assimilation center is required. A report has been prepared by the U.S. WOCE Office and distributed to attendees, to the NSF, and to members of the NRC committee to consider coordination and needs of large ocean science programs, chaired by Rana Fine. Additional copies are available from the U.S. WOCE Office.

A second meeting, organized by a committee consisting of Rainer Bleck, Ken Denman, Dale Haidvogel and Jim McWilliams was held in Boulder, CO in April 1997. The focus was community needs in support of ocean general circulation modeling. Invitations were sent to representatives of CLIVAR, GLOBEC and JGOFS, as well as DOE, NASA and NOAA laboratories (both scientists and laboratory managers), and to several individual scientists in the community who could contribute expertise. (See Appendix I; unfortunately, not all who were invited could attend.) This report details the deliberations of that meeting. It will be submitted to the NSF, the relevant NSF programmatic steering groups, and to the NRC committee mentioned above, after review by the meeting invitees and participants.

II. STRUCTURE OF MEETING

The agenda for the meeting is given in Appendix II. Following a summary of the background to the meeting, McWilliams set out the following premises to guide the subsequent discussion:

1. That Ocean General Circulation Models (OGCMs) are essential for ocean research and its application. This requires support and organization.
2. That the number of scientists interested in using OGCMs in their research, including observationalists, is steadily increasing and is likely to continue to do so. This requires that OGCMs be well supported and managed.
3. That it takes a community to develop a comprehensive, multi-purpose model, given the size and complexity of the task. This requires cooperation and coordination.
4. That GCMs need substantial computing resources, staff support, and sustained efforts for development, testing, and utilization. These require infrastructure, institutional homes, and supercomputing capabilities.
5. That there are many uses for GCMs with substantially overlapping requirements. This infers that they be multi-purpose and multi-disciplinary.
6. That individuals in the academic community who work outside the institutional homes of the models have much to contribute to the design, selection and direction of GCMs, not just their use. This requires shared ownership of the modeling enterprise reaching outside their institutional homes.
7. That models must evolve. This requires a funding, management, and community research framework that fosters variety, flexibility, openness, and scrutiny.
8. (Judging by the above) That the status quo is not optimal, and what most inhibits progress is that individual and most laboratory efforts do not have critical mass. This requires creating more explicit arrangements for pooling contributions.

He then stated the goals for the meeting (see Appendix III). Following talks by Marotzke, Talley, and Denman on future requirements for modeling as part of global programs such as WOCE, CLIVAR, JGOFS, and GLOBEC, representatives of several modeling groups described how their models have evolved and their intended development. Considerable discussion ensued on the need for continued support for OGCM studies. This culminated in a proposal to establish a Community Consortium on Ocean Modeling (see Section IV).

Additionally, the meeting discussed a presentation by Semtner on the present status and future requirements for computational resources devoted to OGCM studies (see Section V).

III. SCIENTIFIC USES OF OGCMS AND PROGRAMMATIC REQUIREMENTS

A. Present Status of OGCMs

Since their inception in the 1960s, oceanic general circulation models have developed into essential tools for ocean sciences. Once quite limited in their complexity and degree of realism, large-scale models of the oceanic general circulation are now widely recognized to have achieved both qualitative (that is, phenomenological) and quantitative (predictive) skill. The prospect is for further substantial gains to be made in the coming years. As the models' sophistication has increased, so has the breadth of their applications: OGCMs are now routinely applied across a broad spectrum of space/time scales for purposes ranging from idealized studies of fundamental processes to multi-decadal and equilibrium simulations of inertial currents and eddy dynamics, climate simulations and predictions, data assimilation, and global biogeochemical cycles.

The number and diversity of available OGCMs has likewise increased, especially over the last decade. Examples include the emergence of isopycnic and topography-following coordinate models as alternatives to the traditional geopotential-based models. Additionally, most aspects of algorithmic design have evolved rapidly (e.g., spatial gridding, treatment of advection, parameterization of sub-grid-scale physical processes). McWilliams (1996) and Haidvogel and Beckmann (1997) provide recent reviews of some of these physical models and methods. Experience with biogeochemical models is also expanding rapidly (e.g., Sarmiento et al., 1993; Six and Maier-Reimer, 1996).

A corollary to the increased diversity and sophistication of today's ocean models is that the systematic implementation, application and distribution of OGCM software and OGCM-derived output now requires a sustained effort involving long-term staff support and substantial computing resources. Clearly, not all potential users of ocean models will be able (or willing) to develop and to maintain their own model. The concept of shared, or community-based, models is therefore attractive, and has become a widely practiced paradigm within the ocean sciences. One example is the Modular Ocean Model (MOM) and its relatives, which include the NCAR Ocean Model (NCOM), the Parallel Ocean Climate Model (POCM), and the Parallel Ocean Program (POP). The Miami Isopycnic Coordinate Model (MICOM), the S-Coordinate Primitive Equation Model (SPEM), and others also fall into this category of community models.

B. Modeling Requirements of National Programs

The future agenda for large-scale ocean modeling within the U.S. is set in part by the needs and goals of ongoing national research programs. Despite progress in model variety, realism and community access, OGCMs need to undergo further systematic evolution and improvement if the long-term goals of these programs are to be met. Examples of programs with explicit and still largely unmet modeling needs include, among others, WOCE, CLIVAR, JGOFS, GLOBEC and CoOP.

The WOCE program has the goals of developing models useful for predicting climate change and collecting the data necessary to test them, as well as providing the global physical context for programs such as JGOFS and GLOBEC. The WOCE Program has recently entered its Analysis, Interpretation, Modeling and Synthesis (AIMS) phase. Recommended activities include an ocean model/data intercomparison project, community efforts directed at model development and data assimilation, and inter-model comparison.

The primary objective of U.S. JGOFS is to gain an understanding of the processes controlling the biogeochemical fluxes of carbon within the ocean and across the air-sea and ocean-sediment interfaces. Meeting this objective will require significant enhancement of our ability to model biogeochemical cycles in the ocean on regional to global scales. This area of modeling is much less advanced than modeling the ocean's physical circulation.

The CoOP program seeks a new level of quantitative understanding of processes that dominate the transports, transformations and fates of biologically, chemically and geologically important material on continental margins. Of particular importance is cross-margin transport. The program operates through a series of observational studies, together with process-oriented and regional modeling.

Finally, GLOBEC has the objective of understanding ocean ecosystem dynamics and how they are influenced by physical processes so that the predictability of population fluctuations in a changing global climate can be assessed. The present focus is on the north-west Atlantic, although a major program in the northeast Pacific (carried out jointly with CoOP) is due to commence shortly. Modeling requirements include the refinement of coupled physical/biological models, particularly food webs, and the embedding of regional ecosystem models within models of the basin-to-global-scale ocean circulation.

C. Examples of Future OGCM Modeling Applications

A chronic difficulty in oceanography is the sparseness of measurements, compared to the breadth of variability that occurs. This mismatch is perhaps most acute for global scale phenomena. In the absence of better measurement techniques, assimilating the available data into skillful OGCMs is probably the most fruitful way to improve our characterization of ocean circulation. Assimilation can be done either in an analysis/forecast mode (as is customary in meteorology), using all recent data to define an initial condition for an integration to forecast a future state, or in an empirical/dynamically consistent mode, where all relevant data are combined with a model solution over the sampling interval to estimate the best synthesis. The present AIMS phase of WOCE clearly could benefit principally from the latter mode of assimilation; in contrast, the proposed basinwide extended climate studies (BECS) to address interannual and decadal variability of the El Nino-Southern Oscillation, the Pacific-North American Oscillation and the North Atlantic Oscillation phenomena (U.S. Ocean CLIVAR, 1996), would employ primarily the former mode. Substantial development of assimilation techniques is still needed, but even after this has been done, the quality of the assimilation products will be strongly controlled by the skill of the OGCMs because of the anticipated continuing sparseness of measurements.

Global and regional climate changes are occurring presently due to human modifications of the environment, although their nature and magnitude are still poorly known relative to the intrinsic natural variability (IPCC, 1996). In multi-year simulation studies of climate variability, changes in the ocean can influence the climate considerably. On short time scales (decades and less), the physical dynamics of the ocean are perhaps more likely than the biogeochemistry to feedback strongly on the climate; however, assessing the consequences in the biogeochemistry is of obvious scientific and economic importance. On longer time scales of climate variation, however, oceanic biogeochemical feedbacks on climate through the radiatively active gases may be more important than the physical ones. To model such behavior requires an OGCM that is accurate with respect to both its equilibrium climate, including internally generated large-scale variability, and its fluctuating exchanges with the atmosphere and sea ice.

The JGOFS, GLOBEC and CoOP programs have overlapping model requirements involving multi-scale nested modeling and global biogeochemical cycles. An example of a multi-decadal, ocean basin scale biogeochemical problem that requires comprehensive coupled models is the synchronous oscillation of the Chilean, Far Eastern and Californian sardine catches in the Pacific since 1910. Catches were low until the mid 1920s, then rose sharply to a peak in the late 1930s, crashed in the 1940s, and remained low for over 25 years before rising again in the mid 1970s (Kawasaki, 1991). Such oscillations are probably caused by global climate variations. Even a retrospective study requires a coupled ocean-atmosphere GCM having an ocean model capable of higher resolution in the coastal margins. Computer resources are also required that can handle century scale runs with embedded ecosystem modules. Similar nested biogeochemical modeling capabilities are needed for the GLOBEC Georges Bank and West Coast projects. However, these capabilities are at present well out of reach.

IV. COMMUNITY CONSORTIUM FOR OCEAN MODELING (CCOM)

The consensus of the meeting was that the national ocean modeling community must integrate and coordinate its presently piecemeal efforts at model development, validation and intercomparison, if the large-scale scientific and programmatic goals of the previous section are to be met within realistic levels of resources and effort. Mechanisms need to be developed to encourage ocean modelers to pool their efforts, and to provide a stable and sufficient funding base for such activities. To this end, the meeting participants endorsed the concept of a "Consortium for Community Ocean Models."

There are some precedents for cooperative modeling activities; for example, the Community Modeling Effort (CME) in WOCE and occasional meetings among scientists working within a common model framework and sharing in the analysis of some of its solutions. Nevertheless, the meeting participants felt that such activities need to be substantially increased, both by encouraging more explicit commitments towards shared responsibilities and by providing better funding opportunities for such cooperative working relationships and the associated infrastructure needed to support them. Meeting participants believe that the consortium could assume important, new roles as an endorser and active spokesman of community modeling activities with respect to the funding agencies. We feel the community would benefit greatly from a structure that goes beyond disconnected individual proposals and enables individual investigators to be funded for work on community-defined problems that require us to reach major technological goals.

Participants agreed that a CCOM should (a) address large-scale scientific problems, such as those associated with NAO, ENSO/PNA, and global change forcing, and (b) adopt a comprehensive (multi-disciplinary, whole-system) modeling approach. More specifically, the Consortium will exist to:

- Coordinate efforts to develop and refine numerical models for use in world ocean circulation, climate and biogeochemistry simulations;
- Coordinate experiments with such models so as to optimally explore the pertinent parameter spaces and provide benchmark solutions;
- Provide infrastructure (personnel for technical support, computing resources, network access, data storage capabilities, meeting and travel funds) to allow mature models to reach the status of true community models;
- Develop versions of these models that serve the specific needs of the biogeochemistry and (coupled) climate modeling communities;
- Develop observational analysis products for forcing, initialization, assimilation, and evaluation of model solutions;
- Promote cooperation between ocean modelers and computer scientists and engineers to ensure that models make efficient use of modern computer architectures;
- Facilitate community access to model output to encourage scrutiny of model results in the light of observational evidence; and
- Create testbeds for innovative algorithms that promise to enhance the computational efficiency or physical correctness of existing models.

The Consortium will operate in a fashion analogous to the large NSF field programs such as WOCE, JGOFS, TOGA, GLOBEC, etc. This will provide members the means to work on larger scientific problems and to participate in the planning and execution of comprehensive modeling activities. It will also require them to work on common, related problems closely coordinated, cooperative teams. CCOM should be viewed as a parallel organization to those of the large field programs, with which it will share the responsibility for accomplishing their scientific goals.

As envisioned by the participants of the meeting, CCOM will consist of a Scientific Steering Committee (SSC) and several Science Teams (STs). The latter will consist of researchers from universities and the large mission laboratories active in OGCMs; each will have a particular class of OGCMs as its focus. The Teams should include or interact closely with model developers, solution analyzers, data comparers, synthesizers and assimilators, and computational scientists. The SSC will be responsible for overseeing and representing community modeling activities and interests as a whole. A primary goal of CCOM is to integrate the efforts of university and laboratory scientists; this can be accomplished only through financial incentives to both communities by the managing agencies and through commitments from the laboratories to contribute scientific leadership, participation and supporting services.

Although dedicated to solving major, multi-faceted scientific problems such as those outlined in WOCE and CLIVAR planning documents, the primary missions of an ST will be to coordinate model development and usage within their model class and to participate in comparisons across model classes via the SSC. The meeting identified the fixed grid (z, sigma) or "level model" family, and the isopycnic or "layer model" family of ocean models as initial model classes for STs because established development and user communities exist for both these model families. New Science Teams could be formed, now or in the future, around e.g., models employing fundamentally new numerical techniques (unstructured horizontal grids, ...), models addressing specific processes (deep convection, local ecological modeling, ...), methodologies of data assimilation (either broad in scope or focused on, e.g., seasonal-interannual climate prediction or the BECS proposed for O-CLIVAR), or models applied in specific geographic regimes such as the coastal zone. However, to achieve the intended community cooperation, the Consortium should spawn new teams via the SSC only where the organizing focus and participating community are clearly defined, and where they do not lead to excessive fragmentation of the community. On the other hand, CCOM should use the STs to encourage a diversity of scientific approaches and allow for continuing evolution, or perhaps an occasional revolutionary succession, in the standard ocean models.

To be successful, the Consortium must be assured of intellectual input from both the oceanographic community at large and the modeling sub-community in particular. A possible mechanism for keeping in touch with the community's needs and priorities, patterned after customs developed in the fixed grid and layer model communities, may be for each Science Team to hold an annual workshop open to everyone with a stake in that team's focus. Model development needs, community calculations, and solution and observational analyses will be identified and prioritized by workshop participants. Volunteers will be sought to take on the identified tasks, and ST membership will be implied by accepting such responsibilities. The ST will elect its own leaders, with rotation being encouraged.

The work of the STs should be coordinated and supervised by a small SSC whose members need not (and whose majority perhaps should not) be the leading members of the individual STs. The SSC will also convene workshops as needed (perhaps in conjunction with annual ST meetings), consider issues that affect the ocean modeling community, consider forming new STs or encouraging the evolution or even disbanding of existing ones, coordinate scientific planning with observational programs, and act in an advisory capacity to the funding agencies. Membership of the SSC will be chosen initially by NSF/OCE and subsequently by self-selection of replacements for members rotating off; in each case, advice will be sought from other interested groups.

As in NSF cooperative field programs, rewards for participation that may encourage researchers to serve on STs and the SSC include the possibility of working on larger problems, participation in comprehensive modeling activities, and better access to funding and computing resources for such ventures.

V. COMPUTATIONAL RESOURCES FOR OCEAN MODELING

A. Assessment of Present and Projected Computer Capabilities

Three types of computer architectures are available to meet the large computational needs of disciplines such as ocean and climate modeling. The first type consists of Parallel Vector Processor (PVP) machines; it includes CRAY vector computers such as the C-90 and the T-90, as well as the NEC SX-4. These three machines with their maximum numbers of processors can be expected to sustain speeds for highly efficient ocean models of about 5, 15, and 25 gigaflops (billions of floating-point operations per second) respectively. These speeds are about 50% of the peak performance of the hardware design.

The second type of architecture has far more processors than the 16-32 usual in the PVP class; such an aggregation of slower single-cpu chips is called a Massively Parallel Processor (MPP) machine. Inter-processor communication and access to distributed memory limit the sustained MPP performance to about 10% of the machine's peak performance on typical ocean problems. Two MPP machines of recent note are the CRAY T3E and the Fujitsu VPP700, which can sustain about 60 and 150 gigaflops, respectively, when configured with maximum allowable numbers of cpus. The third type of architecture is still developing; it consists of tightly coupled multi-processors (TCMP, sometimes called SMP or shared multi-processors), which are assembled from mass-marketed components of workstations or servers. One example is the SGI/CRI Origin 2000 system being developed for LANL, which will sustain 25 gigaflops in 1997 and be upgraded to sustain 250 gigaflops in 1999. (This assumes, however, that the systems can deliver 25% of their peak performances.)

The PVP vector machines are the easiest to program and have been the preferred machine type for model development and usage by the scientific community. The MPPs tend to be somewhat faster, provided extra programming is done to make standard models run efficiently on them. Presently, the fastest PVP and MPP machines (intrinsically and on the basis of cost per gigaflop) are being manufactured outside the United States. The somewhat experimental TCMP architecture is being pursued by U.S. companies such as SGI/CRI, HP, and IBM as a long-range alternative that uses cheaper commodity workstation components rather than custom-made cpus. However, the TCMP machines have an extra level of communication among processors and memory compared to the other architectures; even if this is not a lasting obstacle to performance, such machines may not be competitive until around 1999. It appears that, at present, the major computing needs of ocean modeling might best be served, at least in part, by foreign-made machines until the U.S. alternative technology has proved itself.

B. Estimate of Computing Power Needed for Ocean Modeling

Presently, ocean modeling is being pursued on a variety of platforms at U.S. national laboratories such as NCAR, GFDL, JPL, NRL, and LANL, at the NSF Supercomputing Centers, and at some universities. Historically, each laboratory has devoted about 20 percent of its computing power to ocean modeling. The aggregate computing power sustained at the laboratories is around 50 gigaflops; thus, U.S. ocean modeling uses about 10 gigaflops. However, high resolution regional studies indicate that present global ocean models are unable to do justice to boundary currents and mesoscale eddies unless their present grids are at least doubled in each coordinate direction. This requires 16 times more computing power. The two global models running on a 10-gigaflop machine at Los Alamos therefore really require a 160-gigaflop machine if the relevant physical processes are to be properly resolved. The time scales of integration with these models also should be extended from decades to centuries or longer, not only to approach an equilibrium state and obtain long-term means but also to understand oceanic variability and its influence on climate change and climate predictability.

Substantial skill has been demonstrated also in modeling the large-scale circulation without resolving well boundary currents and eddies. Such models require much smaller amounts of computer time per model year. However, this economic advantage is often reinvested in longer integration times and coupling with climate or biogeochemistry models.

Thus, 1000 gigaflops (i.e., a teraflop) is a reasonable estimate of the computing power required for ocean modeling within the next few years. Even if the highest resolution models are used rather sparingly, there are a variety of important modeling applications at lower resolution---such as investigating paleoclimates, including biogeochemical processes, doing parameter studies, assimilating data, and making ensemble forecasts---all of which necessitate major increases in the overall computing power for ocean modeling in the years ahead. Realistically speaking, the modeling community could now use a ten-fold improvement over that presently available and another ten-fold improvement after a few more years. This could be accomplished by some combination of significant upgrades at some of the laboratories that support oceanographic modeling, by using a sizable fraction of the resources at the NSF National Supercomputing Centers, and/or by making a larger high-end acquisition dedicated to ocean and climate modeling. In any of these situations, the enormous demands for ocean modeling dictate that the very best machines should be selected regardless of where they are made; otherwise the quality of U.S. ocean science will deteriorate drastically relative to elsewhere.

The ocean modeling community should argue strenuously for an increase in its computing resources because the rate of scientific progress is likely to be controlled significantly by what is available. Available resources can, however, be used more effectively if at least some of the largest calculations can be designed and analyzed in a community mode. This will increase both the number of scientists working and issues addressed per solution. Managing these resources will be one important task of the Community Consortium for Ocean Modeling (Section IV).

VI. SUMMARY AND NEXT STEPS

To accelerate the development, testing, and application of Ocean General Circulation Models (OGCMs) through increased cooperation and coordination among interested researchers, we propose that a Consortium for Community Ocean Modeling (CCOM) be established.

This action should follow a widespread circulation of this report for comment---among the meeting participants, the program offices in NSF/OCE and their scientific advisors; the SSCs of the large programs to which this would be relevant (WOCE, JGOFS, CLIVAR, GLOBEC, etc.); the federal laboratories that support ocean modeling (NCAR, GFDL, LLNL, LANL, NRL, GSFC, JPL, etc.); and other potentially interested agencies (NASA, NOAA, ONR, DOE, etc.). If the proposal receives sufficient support, a provisional SSC should be appointed by NSF/OCE, in consultation with the other interested parties, to develop a CCOM Implementation Plan.

VII. REFERENCES

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APPENDIX I - MEETING ATTENDEES

Organizing Committee:

R. Bleck	University of Miami
K. Denman	IOS, Canada
D. Haidvogel	Rutgers University
J. McWilliams	UCLA

Administrators:

M. Blackmon	NCAR
E. Itsweire	NSF
R. Malone	Los Alamos National Laboratory

Individual Scientists:

D. Behringer	NOAA/NCEP
F. Bryan	NCAR
Y. Chao	JPL
P. Chapman	U.S. WOCE Office
S. Doney	NCAR
P. Gent	NCAR
J. Marotzke	MIT
J. Marshall	MIT
D. Pierce	Scripps Institution of Oceanography
A.Semtner	NPGS Monterey
R. Smith	Los Alamos National Laboratory
M. Spall	Woods Hole Oceanographic Institute
L. Talley	Scripps Institution of Oceanography
R. Toggweiler	NOAA/GFDL

APPENDIX II - PROVISIONAL AGENDA

Monday, 7 April
0830: Introduction; purposes of the meeting (McWilliams)

0845: Needs and uses of OGCMs in CLIVAR (Leetmaa/Marotzke)

0915: Needs and uses of OGCMs for biogeochemistry (Denman)

0945: Needs and uses of OGCMs for data assimilation (Bennett)

1015: Break

1030: Experiences of (proto-)community modeling groups with respect to cooperative working relationships, funding, and infrastructure (10 minutes max):
MICOM (Bleck)
MOM (Toggweiler/Mahlman)
POP (Malone/Smith)
NCOM (Gent/Blackmon)
MIT (Marshall/Marotzke)
SPEM/SEOM (Haidvogel)
NCEP (Leetmaa)
POCM (Semtner)
others

1230: Lunch

1330: Discussion 1: Future procedures for developing, testing, selecting, and supporting community models
a) boundaries of community modeling
b) desired working relationships with community models
c) necessary conditions for achieving them

1500: Break

1530: Discussion 2:
a) roles of national laboratories (Mahlman, Malone, Blackmon, Busalacchi)
b) roles of the NSF and other agencies (Itsweire, ...)
c) computational requirements (Semtner, Bennett)
d) model test problems (Haidvogel)

Tuesday, 8 April (AM)
0830: Discussion 3: follow up on issues from day 1

1000: Break

1030: Recommendations and organization of report

1200: Adjourn plenary session

Tuesday, 8 April (PM)
1330: Executive Session

APPENDIX III - CHARGE TO MEETING

The following statement was circulated prior to the meeting:

MEETING STATEMENT

A meeting will be convened to discuss organization, resource needs, and financing of OGCMs, including the topics of model development, model testing, computations, solution analyses, and data comparisons. The focus will be models for calculating global equilibrium states and natural variability on all time scales from weeks and longer. This encompasses their uses for climate (US GCRP), ocean diagnoses and data assimilation (WOCE/CLIVAR), prediction (GOALS/CLIVAR), and biogeochemical cycles (JGOFS/GLOBEC). The product of the meeting will be a report with recommendations to the NSF and other interested agencies.

Calls for the need to improve infrastructure and university-laboratory cooperation for OGCM research have recently been made in the WOCE Synthesis Plan and the O-CLIVAR Implementation Plan. A small steering group representing the major US Global Change Research Programs and the general community has endorsed this concept. Support for the meeting will be by the NSF Division of Ocean Sciences.

PURPOSES

1. To assess the current and future uses and resource requirements for OGCMs.
2. To define procedures whereby institutionally supported models can be used and contributed to by a user community of academic scientists, including the possible adoption of new codes and algorithms.
3. To promote a higher national priority and level of funding for OGCM development and testing (across the federal agencies supporting such modeling: NSF, NOAA, NASA, DOE, and ONR).
4. To achieve better institutional support for a few community models, including the infrastructure requirements for staff, computers, data sets, and code maintenance.
5. To define a process for selecting community models, both now and in the future.
6. To identify requirements and developments necessary for effective use of community OGCMs in biogeochemical applications.